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Joint Contribution from the Bureau of Plant Industry, William A. Taylor, Chief; and the Office of Markets, Charles J. Brand, Chief.
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SPINNING TESTS OF UPLAND LONG-STAPLE COTTONS.[1]

By Fred Taylor, *Cotton Technologist;* and Wells A. Sherman, *Assistant in Market Surveys.*

INTRODUCTION.

Only three years ago the long-staple cotton situation as it then existed in the United States was considered acute by spinners. The Mississippi Delta and the lowlands of Louisiana, which for a generation had been the principal source of supply for cottons ranging from 1⅛ to 1½ inches in length, had been invaded by the boll weevil with disastrous results. So complete was the destruction that considerable areas in Louisiana entirely abandoned the production of cotton. Throughout southern Mississippi and the lower half of the Delta region, early maturing, short-staple varieties were being rapidly introduced because they were found to be more profitable under weevil conditions than were the long-staple varieties then in cultivation. The spinners besought the Department of Agriculture to assist in an effort to maintain the staple industry in the Mississippi Delta. They also raised funds to be expended under their direction in experimental work with the hope of developing new varieties of Delta staple cotton which could be produced profitably in the presence of the weevil.

Those engaged in the breeding work of the Department of Agriculture were already satisfied that excellent Upland cottons of 1¼-inch staple could be produced on the Atlantic slope, but the experiences

[1] The work discussed in this bulletin was carried on as a part of the work of the Office of Cotton Handling and Marketing Investigations conducted jointly by the Bureau of Plant Industry and the Office of Markets. The tests were conducted and supervised in detail by Mr. Fred Taylor, Cotton Technologist, Department of Agriculture, who received every possible courtesy and assistance from the faculty of the New Bedford Textile School. Managing Director W. E. Hatch and Principal William Smith, in charge of the carding and spinning department, rendered special assistance. The facilities of the school were generously placed at the disposal of the department for the purposes of these tests, and due acknowledgment is made of the material assistance thus rendered the investigational work.

Note.—This bulletin is a report of tests of Upland long-staple cotton as compared with Deltas of the 1912 crop. Of interest to spinners and growers of Upland cotton on the Atlantic slope.

of the spinners with so-called long-staple Carolina uplands had been unsatisfactory.

Subsequent investigation seems to indicate that this was because most of the so-called staple cottons produced in this territory had been grown from seed brought over from the Mississippi Delta, which was not acclimated. No adequate care had been taken to keep such importations pure by preventing cross-pollenization in the field or mixing of seed at the gin. Furthermore, few ginners in the Carolinas, outside the Sea Island belt, were familiar with staple cotton, and much of that which they handled was seriously injured in the ginning process.

There were, however, in the Carolinas a few careful breeders who had taken up systematic selection and breeding work with the best strains obtainable of the Columbia variety, which had been developed and introduced by the Department of Agriculture some years before. At the same time this department was developing the Durango cotton in the West. This variety is especially adapted to the irrigated regions of the extreme Southwest and has given excellent results on river bottoms in Texas and in other favorable locations having sufficient moisture. It has recently been grown with marked success as far north as Norfolk, Va.

With the sudden decrease in the staple production of the Delta, Carolina breeders found sale for their best qualities at very satisfactory prices, which stimulated greatly the planting of staple varieties in areas previously given over almost entirely to short cotton. A study of the quality of the staples produced for some years past in certain parts of the Carolinas and of the prices received seems to indicate that the few spinners who understood the true character and value of these cottons added largely to their profits by quietly absorbing the entire output at prices very much below those prevailing for corresponding qualities grown in the Delta. A very large number of spinners, however, still hold to the opinion that Upland staple cottons grown in the Carolinas and Georgia are wholly inferior to those grown in the Delta. They believe the Eastern staples to be more "wasty," that is to say, that they contain a larger proportion of short fibers which will be taken out as waste in the manufacture of combed yarns. The department's breeders have satisfied themselves, by examination in the field, that the best of the new Upland varieties are fully equal in uniformity of staple to the average "Deltas" or "Peelers" of the same length.

The results of the experiments here recorded show the character of the best Upland staples grown in the East to be sufficiently high to warrant spinners in being less conservative in buying them.

It must be remembered that these are the first tests in a new field of investigation. Too sweeping and far-reaching conclusions should

Erratum in Bulletin 121.

On page 19, Table X1, Number of bales of cotton 1-1/8 inches in staple consumed annually by the mills of Indiana should read 3,305 instead of 33,055, thus changing the totals of the first column to 817,684 and that of the last column to 1,097,463.

not be drawn until corresponding tests can be made from the crops of other years and on samples of the same varieties grown under different conditions.

In order to determine how the best strains of the new varieties actually compared in spinning value with Delta cottons, arrangements were made in the fall of 1912 for conducting a series of spinning tests in cooperation with the New Bedford Textile School, New Bedford, Mass. Owing to the miscarriage of two bales in transit, the tests, which were made in May, 1913, included only five bales. These represented four different varieties or strains grown in three entirely distinct regions of production. Two of the bales are of similar origin and represent an early and a late picking, with different methods of handling the seed cotton. The tests showed these Upland cottons to be of such high quality that publication of the results was withheld with the intention of making similar tests on a much larger number of samples and varieties from the crop of 1913. Such tests should show whether the exceptional quality of some of the bales in the first experiments was due in any degree to seasonal conditions.

A very serious situation, however, now confronts the long-staple cotton growers in the Southeast, in view of the fact that the crop the Delta suffered comparatively little from weevil injury during the past season. The prejudice of the spinners still persists against Upland staple from the Southeast, the movement of the crop of 1913 has been exceedingly slow, and during the latter part of the picking season prices were very little above those of short cottons. There is a serious disposition to abandon the long-staple industry just as it is becoming well established on a thoroughly sound basis in the new territory. These conditions make it advisable that both spinners and growers be given all the information in the possession of the department concerning the value of the new Upland staples. The results of the spinning tests thus far made are accordingly presented herewith.

THE VARIETIES TESTED.

The five bales of cotton actually tested were: One bale of Durango, grown on the Brazos bottoms near Waco, Tex.; one bale of Columbia, grown by C. H. Carpenter, near Easley, S. C.; one bale of Lewis, grown by E. P. Lewis, of Gastonia, N. C.; two bales of Webber, grown by E. W. Evans, Bennettsville, S. C., from highly-bred seed produced by J. L. Coker & Co., Hartsville, S. C. Of these two bales, Webber No. 1 was from cotton ginned in November immediately after picking, and Webber No. 2 was from a pile of about 6,000 pounds of seed cotton picked about October 1 and stored six weeks before ginning.[1]

[1] For history of this storage experiment see: Brand, C. J., and Sherman, W. A., Behavior of seed cotton in farm storage. U. S. Department of Agriculture, Bureau of Plant Industry, Circular 123–B. 1913.

The Durango is a variety developed by the Department of Agriculture from a selection made from cotton which came originally from the State of Durango in Mexico. The staple of the bale tested was $1\frac{3}{16}$ inches and the grade good middling.

The bale of Columbia from Easley, S. C., was from a selected strain of that variety carefully bred by Mr. Carpenter. It stapled $1\frac{3}{16}$ inches and graded strict good middling. The season had been adverse in this locality, and this cotton was not as long as is frequently produced by the same strain under more favorable conditions.

The bale of Lewis cotton was obtained from the originator of this variety, who is unable to give a detailed account of its origin beyond the fact that it was developed from a single plant which is believed to have been originally of Delta stock. The entire production of this variety has up to the present time been consumed by local mills. The bale tested stapled a full $1\frac{5}{16}$ inch and graded good middling.

The Webber variety has been developed by Mr. D. R. Coker, of Hartsville, S. C. The original plant was selected from the Columbia variety and was pointed out to Mr. Coker by Dr. H. J. Webber, then of the Bureau of Plant Industry, as closely approximating his ideal of what a Columbia cotton plant should be. By systematic selection Mr. Coker has decidedly improved the length of the staple and has named his strain "Webber" in honor of the originator of the Columbia variety.

It is fair to state that other strains of Columbia in the hands of skillful breeders have shown similar improvement over the original type. The two bales of Webber tested were grown under high fertilization and intensive cultivation by an excellent farmer and represent what may be expected of this variety under favorable cultural conditions. They graded middling and each stapled $1\frac{5}{16}$ inches.

After the bale of Durango cotton was purchased it was brought to the attention of the department that the grower had not been taking measures to maintain the purity or standard of the variety, but had grown it for a number of years in fields adjacent to short-staple varieties. This may account in some measure for the large percentage of short fiber found. It was, however, then too late in the season to secure a bale of better parentage.

SOIL TYPES REPRESENTED.

The Durango grew on Texas river-bottom land heretofore given over entirely to the production of short staples. The Lewis and Columbia were grown in the Piedmont section of North Carolina and South Carolina at elevations of 800 feet or more, while the Webber was produced in the level, Pee Dee River section of the

Carolina Coastal Plain, at an elevation of about 150 feet above sea level.

The tests included, therefore, not only four comparatively little-known varieties or strains, but also represented three distinct producing areas, none of which are generally believed by the cotton trade to be well suited to the production of staple cotton.

It was planned to compare the results obtained from these varieties of Upland long staple with a test on the same machines of Mississippi Delta cotton of similar grade and staple, but before this could be done the textile school closed for the summer vacation.

On February 16, 1914, a finisher picker lap was secured from one of the New Bedford mills, which was believed to represent an average blend of $1\frac{1}{4}$-inch Delta cotton. This lap was composed of a mixture of five different bales, one each from Black Bayou and Beulah, Miss., and Laconia, Henrico, and Archillion, Ark. These bales graded as follows: One bale strict low middling, two middling, and two good middling, and the staple was a full $1\frac{1}{4}$ inch. It was thought that such a composite sample of Delta cotton would more nearly represent an average commercial quality.

The same machines with the same adjustments and settings were used for the Delta test as for the other tests, so that the results should be comparable.

VARIATIONS IN GRADE AND STAPLE.

It will be noticed that three of the bales tested were $1\frac{5}{16}$-inch staple, while two were $1\frac{3}{16}$ inches. There were two middling, two good middling, and one strict good middling bales, while the Delta cotton was a mixture of three grades. Our purchases were made so late in the fall of 1912 that it was impossible to secure all the bales of the same grade, and the difference in grade will account for the great differences in the percentage of waste on the opener, breaker, intermediate, and finisher pickers and card as shown in Table I.

TABLE I.—*Percentage of waste removed at each machine in the picking and carding processes.*

	Variety.					
	Durango, grade G. M.	Columbia, grade S. G. M.	Lewis, grade G. M.	Webber No. 1, grade M.	Webber No. 2, grade M.	Delta blended.
Staple (inches)	$1\frac{3}{16}$	$1\frac{3}{16}$	$1\frac{5}{16}$	$1\frac{5}{16}$	$1\frac{5}{16}$	$1\frac{1}{4}$ full.
Breaker picker	1.125	1.125	.875	2.75	2.50	[1]
Intermediate picker	1.48	.77	.90	1.57	1.57	[1]
Finisher picker	.50	.57	.63	1.26	1.43	[2] 3.70
Card	3.96	4.13	3.70	5.20	5.81	7.03
Total	7.065	6.595	6.105	10.78	11.31	10.73

[1] Not itemized.

[2] Inasmuch as a picker lap was purchased, it is impossible to show the invisible loss in the picker room or the itemized picker waste for the Delta sample. The total picker waste had, however, been ascertained by the mill.

DIFFERENCES IN LENGTH OF STAPLE.

These tests were designed to determine approximately the relative amounts of waste in the several varieties and the breaking strength of yarns made from them. The Delta was included so that comparison of results could be made not only with the ordinary commercial calculations for $1\frac{1}{4}$-inch cotton similarly handled, but also with actual tests of such cotton made on the same machines. Each of the five bales tested in this experiment was run on the same machines and with absolutely the same settings, so that the data were strictly comparable in every way throughout. Notwithstanding the fact that the staple of the different samples varied from $1\frac{3}{16}$ to $1\frac{5}{16}$ inches, they were all put through the machines with the settings used for $1\frac{1}{4}$-inch cotton, because each of the varieties tested is believed under favorable conditions to be in competition with $1\frac{1}{4}$-inch Delta staples. The Columbia and Durango were apparently at a disadvantage in this test, because with their shorter staple they would naturally give an increased percentage of waste. Table I shows, however, that the total picker and card waste was very nearly in proportion to grade, the Lewis apparently being slightly better than the others.

THE INVISIBLE LOSS.

The invisible loss, which is shown in Table II, is caused chiefly by loss of moisture and also to some extent by dust and short fibers which are lost in the air during the operation of stripping at the card. There is no appreciable invisible loss after the cotton has passed through the card, as all dust, short fly waste, and excessive moisture have been removed. The percentage of humidity maintained affects the amount of invisible loss, as the greater the humidity in the mill the more moisture will be retained in the cotton within certain definite limits. There being no humidifying apparatus in the picker, card, and comber rooms at the New Bedford Textile School, the humidity during these tests could not be regulated. It will be seen in Table II that the invisible loss is greater in the low grades, probably because they contain more dust and light trash.

TABLE II.—*Percentage of invisible loss at each machine in the picking and carding processes.*

	Variety.					
	Durango, grade G. M.	Columbia, grade S. G. M.	Lewis, grade G. M.	Webber No. 1, grade M.	Webber No. 2, grade M.	Delta blended.
Breaker picker	1.875	0.375	1.125	1.75	2.00	[1]
Intermediate picker	.58	.77	.38	.78	.52	.....
Finisher picker	.071	.144	.49	.31	.57	.....
Card	.503	1.31	.48	1.49	.72	0.62
Total	3.029	2.599	2.475	4.33	3.81	.....

[1] No invisible loss is shown for the Delta cotton up to the card, as this sample was started at that machine. This blend contained one strict low middling, two middling, and two good middling bales.

CARD WASTE.

The function of the pickers is to remove from the cotton all the heavier impurities such as sand, hulls, stems, bunches of neppy fibers, broken seed, etc., while the card removes the smaller impurities such as neps, tangled fibers, minute particles of trash and leaf, and a small percentage of short fibers. The card waste is itemized in Table III.

TABLE III.—*Percentage of each type of card waste obtained from each variety.*

	Variety.					
	Durango, grade G. M.	Columbia, grade S. G. M.	Lewis, grade G. M.	Webber No. 1, grade M.	Webber No. 2, grade M.	Delta blended.
Stripping waste[1]	0.69	0.85	0.73	1.12	1.82	1.62
Flat stripping waste[2]	2.41	2.53	2.40	2.62	2.54	3.64
Licker in and screen waste[3]	.86	.75	.57	1.46	1.45	1.77
Total card waste	3.96	4.13	3.70	5.20	5.81	7.03

[1] Card stripping waste is composed of short fibers that slip down in the spaces between the wires of the card clothing. This waste is chiefly composed of fibers up to about ⅜ to ½ inch in length with some longer fibers.

[2] Flat stripping waste is composed of neps, tangled fibers, gin-cut or damaged fibers, motes, and all those fibers that do not readily disentangle and which adhere to the flats.

[3] Licker in and screen waste is composed of extremely short fibers and minute particles of seed, sand, leaf, stalks, etc., and those fibers that fly from the general mass and drop through the screens underneath the card.

RELATION OF GRADE TO WASTE.

When the cotton has passed the card almost all foreign matter has been removed. The greater part of those fibers below three-eighths to one-half inch in length have also been separated. A glance at Table I will show that the Webber bales contained from 4 to 5 per cent more foreign matter than the other three, but it must be noted that the grade of these two is middling, while the others are good middling and strict good middling. The mixture of Delta cotton, which averaged slightly better than middling, compares closely with Webber. Thus 4 to 5 per cent on a 500-pound bale amounts to 20 to 25 pounds of cotton waste. This at 20 cents per pound amounts to $4 to $5 per bale, a difference equal to 80 to 100 points in value.

It is now of interest to compare the waste percentages up to and including the card in the case of the two middling bales with that of the two good middling bales. The total waste itemized in Tables I, II, and III is obtained by adding the picker waste, card waste, and invisible loss. The two middling bales show an average of 15.11 per cent, and the good middling an average of 9.34 per cent, a difference of 5.77 per cent in favor of the good middling. However, it must be stated that this does not represent the true relation of values between grades, as there are a number of other factors which in-

fluence more or less the value of cotton to a spinner. If we compare a 500-pound bale of middling with a 500-pound bale of good middling on the basis of the above percentages, ignoring tare, we find that the middling bale produces 424.45 pounds of yarn or thread, while the good middling produces 453.30 pounds. These figures show a difference in the amount of finished product of 28.85 pounds, which represents an important item to the manufacturer, as this 28.85 pounds, if it had not been removed as waste, would have appeared as finished yarn and thus would be worth the value of the finished product. Again, the machines must be operated just as long, at the same or greater cost to the mill, to produce the 424.45 pounds from the middling bale as they are to produce the 453.30 pounds from the good middling bale.

Again, the machines can not run as fast or produce as much when running on low grades as when on the higher grades. Therefore it is apparent that increased labor charges per pound accrue on a decreased outturn of production. This is due to the increased percentage of waste and necessarily slower speeds, and it is necessary either to operate with a lower production or to overcome these factors by running double shifts of operators on some processes or by increasing the equipment for these processes, either of which is an expense to the manufacturer, and adds its influence to the relation of values between the grades.

Again, on account of the increased amount of foreign matter in the lower grades such machines as the picker and card require more frequent cleaning or "stripping." This necessitates more frequent stoppage of the machinery for this purpose, especially of the cards, which reduces production and increases cost. It should be remembered also that the low grades of staple cotton have only a very limited use in the regular or so-called white lines of goods. It is sometimes the custom to mix low grades of off-colored cottons in very small quantities with the better grades. If a great number of low-grade bales should be put through the mill simultaneously the color of the yarn or cloth would likely be of such character as to be considered by the trade as undesirable, or difficult to bleach, or to dye with such delicate shades as are sometimes used. This attitude of the trade accounts largely for the discrimination against the low-grade staples. It is a question how far this discrimination should be carried, as frequently these low grades, after being cleaned of their excessive trash, are almost as valuable to the spinner as the better grades.

Summarizing these statements it seems that every increase of waste or of labor necessary and every per cent by which production is decreased increases the final cost per pound to the mill. The important fact is that even with a reduced production all overhead or fixed

expenses at the mill, such as heat, light, power, clerical force, fixed salaries, insurance, etc., continue on the basis of the larger production. Thus it will be seen that other factors than the percentage of waste in the different grades should and do influence the values of those grades to the spinner.

COMPARISONS AT THE COMBER.

Since all these samples were put through the same machinery under identical speeds, drafts, and weights per yard, it is assumed that they arrived at the comber with approximately similar waste contents. The percentages shown on the comber, therefore, should be strictly comparable. It must be borne in mind that the five tests were performed without the slightest mechanical alteration on the comber, which was so adjusted as to remove 13 to 15 per cent waste or short fiber from 1¼-inch cotton under ordinary mill conditions. The Delta sample was put through the same machine with the same settings about 10 months later.

TABLE IV.—*Actual comber waste with the 13 to 15 per cent setting.*

	Variety.					
	Durango, grade G. M.	Columbia, grade S. G. M.	Lewis, grade G. M.	Webber No. 1, grade M.	Webber No. 2, grade M.	Delta blended.
Comber waste, per cent.....	13.01	10.71	8.08	13.07	11.56	12.92

It will be seen that the greatest difference occurs between Webber No. 1 and the Lewis samples, viz, 4.99 per cent, or practically 25 pounds of cotton per bale. At 20 cents per pound this equals $5, and would justify a premium for the Lewis of nearly 1 cent per pound.

One of the most interesting results of this test is the wide variation shown by these varieties in the percentage of short fibers removed by the same machine. It was to be expected that the Delta cotton would compare favorably with Eastern long staple varieties, but it is seen that with a comber setting of 13 to 15 per cent this lot is among the three bales showing the largest percentage of waste. The highest percentage of waste removed from any one bale exceeded the waste removed from the Delta sample by only fifteen hundredths of 1 per cent, while the Delta loss exceeded that of the Columbia by 2.21 per cent and that of the Lewis by 4.84 per cent. The average loss of the two Webber bales was 12.32 per cent as compared with 12.92 per cent loss by the Delta, which was composed of 5 typical

bales from as many Delta markets. It seems probable that had these 5 Delta bales been tested separately instead of in a mixture, some of them would have proved inferior to any of the Upland bales tested.

The Columbia and the Lewis varieties appear very much superior to the other bales tested in "body" or uniformity, and give results far better than the usual mill estimate for cottons of their lengths. The geographical comparison is interesting. The commercial calculation was for a loss of 13 to 15 per cent. The one Texas bale lost 13.01 per cent; the five Delta bales mixed, 12.92 per cent; the four Carolina bales averaged 10.105 per cent.

COMBER TESTS WITH WIDE SETTINGS.

After these tests were completed, the combing machine was adjusted so as to remove 23 to 25 per cent waste and another test of each bale was made with the following results:

TABLE V.—*Percentage of fiber removed as waste from each sample with comber at 23 to 25 per cent setting.*

	Variety.					
	Durango, grade G. M.	Columbia, grade S. G. M.	Lewis, grade G. M.	Webber No. 1, grade M.	Webber No. 2, grade M.	Delta blended.
Comber waste, per cent.....	20.43	16.15	12.15	21.81	18.10	16.15

The most remarkable thing about these tests is the great difference between varieties in the amount of comber waste and the very low waste content of Columbia and Lewis.

The widest range between bales occurs between Webber No. 1 and Lewis, viz, 21.81 and 12.15 per cent, a difference of 9.66 per cent in the amount of short fibers removed. These two bales were approximately the same in length of staple. This difference is equivalent to almost 50 pounds of cotton per bale. At 20 cents per pound this is equal to $10, or 2 cents per pound.

Samples of cotton from these two bales were shown to a large number of brokers and others, and the opinion generally expressed was that, by the method of "classing" or stapling ordinarily employed it was practically impossible to distinguish between them, in spite of the fact that the difference in waste would equal 50 pounds per bale.[1]

[1] Cook, O. F. The relation of cotton buying to cotton growing. U. S. Department of Agriculture, Bulletin 60. 1914.

It is noteworthy that the actual waste obtained was in every case decidedly below the usual mill estimate for this wider setting. The Lewis bale again showed the least waste, while the Columbia and the Delta lost identical percentages.

Averaging the two Webber bales we have the following showing for the five varieties as compared with the arbitrary commercial or standard expectation of 24 per cent of loss at this setting. The order of excellence then appears as follows: The Lewis showed an actual loss of 11.85 per cent less than the standard. Columbia and Delta each showed 8.85 per cent less. Webber showed 4.04 per cent and Durango 3.57 per cent less, respectively.

Compared geographically the Texas bale showed a total waste on the wide setting of 20.43 per cent; the Delta, five bales mixed, lost 16.15 per cent; the Carolina staples, four bales averaged, lost 17.05 per cent. Special attention is called to the fact that the bale of Columbia which exactly equaled the Delta in this test was one-sixteenth inch shorter cotton than any of the others, save Durango, and must have possessed superior uniformity, else it would have lost more than the longer staples.

The very slight superiority shown by the Delta over some of the Carolina staples at this wider setting does not offset the much greater superiority of the Carolinas over the Deltas at the 13 to 15 per cent setting, the latter being more frequently used in actual millwork.

NUMBER AND UNIFORMITY OF TESTS.

A study of the large number of percentage tests and weighings made on each variety, as shown in Table VI, ranging from 17 on Lewis to 36 on Webber No. 1, shows conclusively that at no time during the run on any bale was the variation sufficient to cause any uncertainty as to the amount of short fiber contained in the sample. The widest variation between any two weighings on the same variety is found in the Durango, namely, 1.48 per cent. In the Delta the widest variation was 1.43 per cent. Even under the most ideal conditions the machinery builders never claim for their combers less than about 2 per cent variation for different runs on the same cotton, even on the best Peelers and Egyptians. It appears, therefore, that each of the varieties tested was practically uniform throughout the entire run made upon it, such variation as occurred being within the limits of error of the machine. The weighings or tests were made at intervals of 10 to 20 minutes during a two to three day run on each bale.

TABLE VI.—*Actual percentages of waste on all comber tests with 13 to 15 per cent setting, with totals and averages.*

Durango.	Columbia.	Lewis.	Webber No. 1.	Webber No. 2.	Delta.
13.73	10.94	7.69	13.7	11.4	12.93
13.79	10.66	7.74	13.7	11.8	12.57
13.39	10.51	9.00	13.5	11.8	12.57
13.20	10.33	7.94	13.5	11.8	12.37
12.64	10.30	8.24	13.0	11.9	13.33
13.72	10.61	8.35	12.4	11.4	12.48
13.79	10.93	8.19	12.7	11.5	13.50
12.40	10.70	7.75	13.0	11.6	12.83
12.60	10.50	8.37	12.5	11.7	12.65
13.30	10.64	8.14	12.4	11.6	13.10
13.77	10.80	7.70	12.5	11.2	12.26
13.01	10.88	7.70	13.0	11.6	13.42
12.53	10.61	8.19	12.8	11.7	13.69
12.89	10.51	8.11	13.2	11.6	13.14
12.91	10.14	7.91	13.5	11.1	12.75
12.73	11.12	7.94	13.5	11.1	13.16
12.99	11.24	8.34	13.5	11.0	12.86
13.01	11.41		13.5	11.3	12.69
12.98	10.84		13.0	11.7	12.54
12.80	10.61		13.2	11.5	12.45
12.31			12.9	11.8	13.43
12.54			12.8	11.8	13.53
12.91			12.8	11.7	
12.36			12.8	11.9	
			13.0	11.6	
			13.1		
			13.3		
			13.0		
			13.3		
			13.0		
			13.0		
			12.9		
			13.0		
			13.2		
			13.2		
			13.1		
[1] 13.01	[1] 10.71	[1] 8.03	[1] 13.07	[1] 11.56	[1] 12.92

[1] Average.

DETAILS OF THE TESTS AT THE WIDE SETTING.

The machinery was run for approximately one full day on each bale at the 23 to 25 per cent setting, and test weighings were made at a little less than hourly intervals. The uniform quality of each bale is again shown, the variations being little greater than at the closer setting.

TABLE VII.—*Actual percentages of short fiber removed as waste with comber set to remove 23 to 25 per cent, by individual tests.*

Durango.	Columbia.	Lewis.	Webber No. 1.	Webber No. 2.	Delta.
19.32	15.45	12.01	21.21	17.97	15.55
19.58	15.03	11.92	21.27	17.16	15.70
20.50	16.29	12.19	21.34	18.75	15.73
20.84	15.91	11.73	21.14	18.63	15.62
20.60	16.00	12.27	22.64	18.38	16.18
20.96	15.43	12.64	22.18	18.18	16.54
20.69	16.64	12.79	22.81	17.94	16.63
20.30	16.82	11.66	21.87	17.81	16.54
21.08	16.79				16.84
	17.09				
[1] 20.43	[1] 16.15	[1] 12.15	[1] 21.81	[1] 18.10	[1] 16.15

[1] Average.

VALUE OF WASTE DIFFERENCES.

In order that the relative values may be shown, the difference in percentages has been converted into pounds on the basis of a 500-pound bale. In Table VIII the second column shows the waste that would have been removed if the comber had taken out the theoretical amount. The third column shows the pounds actually removed. The fourth column shows the difference between these two. The last column shows the actual value of this difference per bale of cotton, at 20 cents per pound, this being an average price when the cotton was bought.

TABLE VIII.—*The commercial calculation and actual comber waste removed per 500-pound bale at 13 to 15 per cent setting, with value of difference, in dollars, per bale.*

Variety.	Commercial calculation at 14 per cent.	Pounds actually removed.	Difference in pounds.	Difference in value at 20 cents per pound.
	Pounds.			
Durango	70	65.05	4.95	$0.99
Columbia	70	53.55	16.45	3.39
Lewis	70	40.40	29.60	5.92
Webber No. 1	70	65.35	4.65	.93
Webber No. 2	70	57.80	12.20	2.44
Delta	70	64.60	5.40	1.08

It must be remembered that the actual value per pound of the cotton after it has passed the comber is considerably more than 20 cents. There is at least 5 per cent tare on the bale. Table I shows an average loss of picker and card waste of 8.76 per cent. Table II shows an average invisible loss of 3.25 per cent, and Table IV shows an average comber waste of 11.56 per cent on the 13 to 15 per cent setting. Adding these losses, we get a total of 28.5 per cent tare and waste removed from the combed cotton, so that the actual value of the product from the comber with this setting is not 20 cents, but at least 25.71 cents per pound.

In addition to these losses in weight there has accrued a labor charge of at least 2 cents per pound and an overhead or fixed charge of like amount, so that the net cost to the mill of the combed cotton is about 30 cents per pound.

If the amounts for the last column of Table VIII are figured on a value to the mill of 30 cents per pound, the results show the additional worth of the Durango to be $1.38 per bale; of the Columbia, $4.93; of the Lewis, $8.88; of the Webber No. 1, $1.39; of the Webber No. 2, $3.66; and of the Delta, $1.62. These are based on the commercial calculation for the 13 to 15 per cent setting.

Only a part of this waste is an absolute loss to the spinner, as the card and comber wastes are sold to coarse-goods mills, waste factories,

mattress factories, etc. Ordinarily the bagging and ties sell for about one-half to 1 cent per pound. Some of the picker waste brings one-half to 2½ cents per pound. Flat strips sell for 60 to 70 per cent of the value of middling Upland cotton. Card strippings are worth 70 to 80 per cent of the value of middling, and comber waste from the better grades usually sells at the price of middling Upland cotton.

The second column in Table IX shows the waste that would have been removed if the comber had taken out the theoretical amount with the 23 to 25 per cent setting. The third column shows the pounds actually removed. The fourth column shows the difference between these two, while the last column shows the actual value per bale of this difference at 20 cents per pound, the price actually paid for this 1¼-inch cotton.

TABLE IX.—*The commercial calculation and actual comber waste per 500-pound bale at 23 to 25 per cent setting, with value of difference in dollars per bale.*

Variety.	Commercial calculation, at 24 per cent.	Pounds actually removed.	Difference in pounds.	Difference in value at 20 cents per pound.
	Pounds.			
Durango	120	102.15	17.85	$3.59
Columbia	120	80.75	39.25	7.85
Lewis	120	60.75	59.25	11.85
Webber No. 1	120	109.05	10.95	2.19
Webber No. 2	120	90.50	29.50	5.90
Delta	120	80.75	39.25	7.85

Again, the figures shown in the last column are those for raw cotton at 20 cents per pound. However, in order to get the actual value of the difference at this point we must now take into account, as before, the tare, waste on pickers and cards, the invisible loss, and the average actual comber waste of 17.46 per cent on the 23 to 25 per cent setting. These various factors make a total of 34.47 per cent loss when the cotton has passed the comber, so that the actual value of the cotton from the comber is not 20 cents, but 26.90 cents per pound. Adding again the labor and overhead charges the cost to the mill of the cotton from the comber will be about 31 cents. Therefore, if the values as shown in the last column of Table IX are calculated on the basis of 31 cents per pound the Durango would be worth, per bale, $5.53; the Columbia, $12.26; the Lewis, $18.36; the Webber No. 1, $3.39; the Webber No. 2, $9.14; and the Delta, $12.26 more than the commercial calculation on the 23 to 25 per cent setting.

A comparison of the values given in the last column in Table VIII shows that all the Carolina cotton, if averaged on the 13 to 15 per cent setting is better than the commercial calculation by $3.17 per bale, while the Delta is $1.08 better. This shows a difference of $2.09 per

bale in favor of the Carolina staple cottons as against the Delta, while on the 23 to 25 per cent setting the average of the Carolina cotton shown in the last column in Table IX is $6.95, and that of the Delta $7.85, a difference of 90 cents per bale, in favor of the Delta on the wider setting.

The grade of the samples being tested does not appreciably affect the quantity of the comber waste, as is shown by comparing Durango and Lewis, both of which are good middling, but which show a difference of 8.28 per cent in comber waste on the 23 to 25 per cent setting.

ACCURACY OF THE MACHINE WORK.

The following mathematical formulæ show that the variations in percentages between the 13 to 15 per cent and 23 to 25 per cent settings on the bales showing highest and lowest waste are consistent with the mechanical changes involved:

25÷15=1.66, the ratio between the two settings.

21.81÷13.07=1.668, the ratio between the two percentages actually obtained on the Webber No. 1.

12.15÷8.08=1.504, the ratio between the two percentages actually obtained on the Lewis cotton.

The mechanical construction of the comber is such that all fibers up to any desired length are taken out, so that these results represent fairly the inherent value of each bale tested, when used for fabrics which require combed yarns. If later tests substantiate the findings of this report, namely, that these bales are representative of inherent differences in the varieties represented, as there is every reason to assume, the great importance to the spinner of knowledge concerning the varieties of cotton purchased for his mills will be fully demonstrated. It is not safe to assume, however, that the same differences will be found between representative bales of these varieties when the latter are grown under radically different climatic conditions. In other words, uniformity may prove to be a much more constant characteristic of some varieties than of others.

FACTORS INFLUENCING WASTE.

There are a multitude of factors which influence the percentage of waste in such tests as those here discussed. If cotton is picked and ginned while damp, or is ginned at too high speed, even the best varieties may be so damaged as to show large percentages of card and comber waste. The mixing of long and short staple seed, at the gin or otherwise, results in the production of cotton lacking uniformity or "body."

After the cotton has reached the mill it is still possible to get varying results from the same bale by running the beaters too fast, thus breaking the fibers, by feeding too heavily, or by operating with improper adjustments of beater grids, or by allowing too strong an air current on the pickers.

On the card it is possible to get a wide variation in results, even when the machine is supposed to be adjusted accurately. The reason for this is that the most important settings or adjustments are made anywhere between five and fifteen one-thousandths of an inch. A difference of one or two thousandths will measurably affect the per cent of waste. It is therefore apparent that only the most painstaking care can obviate these possibilities of error. Again, if the speed of certain parts of the card is varied, or if a heavier lap is fed, or if the grinding of the steel wire clothing of the cylinder, doffer, or revolving flats is neglected, or if the stripping of these is too infrequent, a varying amount of waste will result.

At the comber a number of conditions may cause a variation in the amount of waste. Among these are differences in speed, in the angle of the top comb, in the distance between the nippers and the detaching rolls, in the weight of the lap, in the rate of feed, the timing of the parts, etc. If any of these factors are changed, even in a slight degree, a different result is obtained. The temperature and humidity also affect the results of such tests.

Items enough have been enumerated to show the possibility of error in tests of this nature. However, as all of these tests were made on the same machines, and all except the Delta, at the same time, and without the slightest mechanical change, the results obtained are strictly comparable as to five samples and very closely comparable as between these and the Delta.

TESTS OF BREAKING STRENGTH.

Table X shows the breaking strength in pounds per skein of the carded and combed yarns. All varieties were spun into 50s yarn, and the twist per inch was calculated as follows: The standard twist factor for filling yarns being 3.25, this factor, multiplied by the square root of the counts (50s) gives the twist per inch thus: $\sqrt{50}=7.07$; $7.07\times3.25=22.97$ turns per inch.

In preparing the yarn for these breaking strength tests it is the custom of the trade to reel off a skein containing 120 yards. The reel is 54 inches in circumference, and when the skein is attached to the testing machine it is an endless length of yarn. This skein is hung upon two hooks and when the tester is started these hooks begin to draw slowly apart. The strength of the skein is registered on a dial.

TABLE X.—*Breaking strength in pounds per skein of carded yarns and of combed yarns resulting from the 13 to 15 per cent comber settings.*

Variety.	Staple.	Carded yarn.	Combed yarn.	Difference.	
				Pounds.	Per cent.
Durango	$1\frac{3}{16}$	24.03	33.07	8.94	37.6
Columbia	$1\frac{3}{16}$	25.56	34.50	8.94	34.9
Lewis	$1\frac{5}{16}$	34.93	41.92	6.99	20
Webber No. 1	$1\frac{5}{16}$	25.88	32.12	6.24	24.1
Webber No. 2	$1\frac{5}{16}$	26.13	33.47	7.34	28.1
Delta	$1\frac{1}{4}$	32.98	42.05	9.07	27.5

The last column of this table shows that the combed yarn ranges from 20 to 37.6 per cent stronger than the carded. The increased breaking strength of the combed yarn is due to the fact that most of the short fibers have been removed by the comber. It is safe to assume that fabrics made of combed yarns possess better wearing qualities than similar fabrics made of carded yarns.

An analysis of Table X shows that there was but slight difference in strength between the yarns made from Durango, Columbia, and Webber. These varieties, whether spun from the carded or combed cotton, appear to be closely comparable in this respect. The Lewis and Delta varieties, however, here show a marked superiority over the others, their breaking strength being from 25 to 33 per cent greater in carded yarns and slightly more than 25 per cent greater in combed yarns. The carded yarn from Lewis had a breaking strength practically 2 pounds greater than that from Delta, while the combed yarn from Delta was thirteen one-hundredths of a pound stronger than that from Lewis. It is notable that the yarns made from the Delta types, which are usually small-bolled cottons, were stronger than those from the big-bolled types, and that the Lewis, which seems to be an acclimated strain of Mississippi cotton brought several years ago to the Piedmont section of North Carolina, is fully equal in strength to the native Delta cottons.

CULTURAL CHARACTERISTICS.

The purpose of this publication is to show the comparative spinning values of the varieties tested, but it must not be assumed that their relative value to the farmer is the same as to the spinner. The Columbia, Webber, and Durango have much larger bolls than the Lewis and are much more rapidly picked. In a number of test plots, where single rows of 16 varieties of staple cotton have been grown for comparison, the Lewis has been among the lowest in yield and in gross value per acre when calculated at the same price, while Durango and Columbia have stood high. The percentage of lint to seed in the Lewis has been lower than in the Durango and Columbia. The de-

partment therefore can not recommend the Lewis variety for general planting in the Southeast except in cases where the grower is reasonably assured of a substantial premium. He should have a premium not only over the price of short cotton, but over the price paid for other Upland 1¼-inch cottons. If he can get a premium for his length of staple only, he can probably grow the more productive varieties with greater profit.

COMPARISON OF EARLY AND LATE PICKED COTTON.

It is interesting to follow the two bales of Webber through these tests and to note the differences between them. Both bales were middling in grade and came from the same field. Webber No. 1 was picked and immediately ginned during the early part of November, while Webber No. 2 was picked about one month earlier and was stored six weeks before ginning. The early picked bale shows better quality in the comber tests with both the close and wide settings. Adding picker, card, and invisible waste, we get for Webber No. 1, 15.11 per cent and for Webber No. 2, 15.12 per cent. These figures show that the grade governs the waste to this point. However, on the 13 to 15 per cent comber setting, Webber No. 1 lost 13.07 per cent and Webber No. 2, 11.56 per cent, a difference of 1.51 per cent in favor of Webber No. 2, while with the 23 to 25 per cent setting Webber No. 1 shows 21.81 per cent and Webber No. 2 shows 18.10 per cent loss, a difference of 3.71 per cent in favor of the cotton picked early and stored before ginning.

The values shown in the last column of Tables VIII and IX are also in favor of the Webber No. 2, as these values correspond with the percentage of comber wastes.

The average breaking strength of the Webber No. 2 is measurably greater than that of Webber No. 1, as shown in Table X.

We might infer from this showing that in normal seasons the earlier cotton is more desirable than the late pickings from the same field, even though the latter are of the same grade and have sustained no visible damage. There is a widespread belief that the length and strength of cotton increases when it is allowed to lie in bulk for some time between picking and ginning. In this test no difference in length was discernible, and the difference in the amount of short fiber taken out by the comber could hardly be attributed to storage. Greater strength is the only remaining factor of superiority in the Webber No. 2, and it is wholly unsafe to assume that this was due to storage. It would be necessary, in order to determine this point, to test bales picked at the same time, one of which had been stored in the seed, while the other had been immediately ginned.

CONSUMPTION OF STAPLE COTTON IN THE UNITED STATES AND CANADA.

In the fall of 1912 a letter was addressed to each of the cotton mills in the United States and Canada, asking for a statement of their average annual consumption of cotton of each of the different commercial staple lengths. Detailed replies were received from practically all of the mills, and the result of this inquiry is shown by States in Table XI. Some of the mills reported their exact consumption for the last preceding year; others reported their average consumption for a period of three to five years.

These figures can not be absolutely accurate, because one mill may designate its cotton as $1\frac{3}{16}$ inches, while another mill, using exactly the same cotton, might call it $1\frac{1}{4}$ inches.

Table XI represents as nearly as possible only Upland staples of American cotton. A special effort was made to secure separate reports on all Sea Island and Egyptian, and also of all cotton of $\frac{1}{16}$-inch staple or less.

It will be seen that the average consumption of Upland staple cotton of $1\frac{1}{8}$ inches or more in length is considerably over 1,000,000 bales, or more than one-fifth of the entire American consumption of raw cotton, the total number of bales consumed for the entire United States and Canada being reported as 5,429,916.

TABLE XI.—*Number of bales of cotton of each length of staple consumed annually by the mills of the United States and Canada.*

State.	$1\frac{1}{8}$ inches.	$1\frac{3}{16}$ inches.	$1\frac{1}{4}$ inches.	$1\frac{5}{16}$ inches.	$1\frac{3}{8}$ inches.	Total.
Alabama	8,437	2,100	1,500	.....	.....	12,037
California	2,000	500	.....	.....	.....	2,500
Connecticut	26,427	9,340	5,718	500	4,500	46,485
Georgia	36,555	12,020	3,600	.....	.....	52,175
Indiana	33,055	.....	.....	.....	.....	33,055
Kentucky	.....	500	700	.....	.....	1,200
Louisiana	11,000	.....	.....	.....	.....	11,000
Maine	47,400	9,950	150	950	80	58,530
Maryland	4,264	.....	.....	.....	.....	4,264
Massachusetts	248,035	41,924	25,158	3,434	16,578	335,129
Mississippi	3,100	.....	.....	.....	.....	3,100
Missouri	.....	.....	.....	6,381	.....	6,381
New Hampshire	147,809	.....	4,146	500	1,500	153,955
New Jersey	8,714	.....	900	.....	2,942	12,556
New York	2,000	814	1,500	.....	.....	4,314
North Carolina	76,290	25,300	16,600	5,000	2,400	125,590
Oklahoma	800	600	.....	.....	.....	1,400
Pennsylvania	2,619	30	1,000	.....	2,025	5,674
Rhode Island	86,248	14,869	15,145	4,843	6,138	127,243
South Carolina	26,932	5,100	8,984	6,250	1,000	48,266
Tennessee	1,400	.....	.....	.....	.....	1,400
Texas	5,070	500	.....	.....	.....	5,570
Virginia	.....	900	.....	.....	.....	900
Vermont	3,300	.....	1,200	.....	.....	4,500
Canada	65,979	2,000	2,000	.....	.....	69,979
Total	847,434	126,447	88,311	27,858	37,163	1,127,213

CONCLUSIONS.

These tests show that careful breeders in the Carolinas are producing cotton fully equal in almost every respect to average Deltas of the same length. They also show that several strains now grown in commercial quantities in the Southeast are less wasty than average Deltas, although not so strong. These varieties are earlier, have larger bolls, and are usually more prolific than Delta types.

These uniform varieties are the result of intelligent breeding work. The importance to the spinner of such work can hardly be overestimated. It suggests the wisdom of more direct dealing between spinners and careful producers, that the latter may be guaranteed suitable premiums for their superior products.

It is possible that there was some peculiarity in the season of 1912, either in the Delta or in the Southeast, which caused these tests to give exceptional results. Material is now in hand for more comprehensive tests on bales of several varieties grown in 1913. If the results of later tests confirm those already made, the wisdom of basing mill purchases on variety as well as upon grade and apparent staple will be fully demonstrated.

The greatest care on the part of buyers in "stapling" cotton will not reveal the difference between two samples which contain 10 and 20 per cent of comber wastes, respectively. If two competing mills were continuously supplied with these two qualities, the difference might easily mean wealth to the one and bankruptcy for the other. The methods now employed by the best cotton breeders enable them by field inspection to judge the uniformity of the cotton more accurately than can any buyer or spinner by examination of samples from the bale.

We seem to be rapidly approaching the time when it may be possible to standardize our pure varieties. If the spinner is wisely to serve his own interests he must modify his buying system in such a way as to see that superior varieties are recognized as varieties, not merely as cottons of a certain length or coming from a certain territory. Such recognition will stimulate pure-seed work and better cultural methods.

The system now prevailing in the primary markets does not assure the grower sufficient recognition of an exceptional product. The indifference of spinners to the improvement of our marketing system is the chief obstacle to a rapid increase in the production of pure-bred staple cottons of superior uniformity.

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